Program	Campaign	Work Scope ID. No.	Work Scope Description
FCR&D	FCR&D Used Nuclear Fuel Disposition	FCD-1	Develop innovative used fuel and nuclear waste interim storage concepts capable of at least 100 years duration. Include multi-year test plans followed by reports describing technical results and efficacy of new technologies.
FCR&D	FCR&D Used Nuclear Fuel Disposition	FCD-2	Development of advanced methods for evaluation of the performance of waste disposal forms—in a variety of geologic media and over geologic time scales—of used nuclear fuel and specific waste forms for fission products, including iodine, krypton, tritium, and carbon-14. The focus of this work scope is on geologic repository performance.
FCR&D	FCR&D Used Nuclear Fuel Disposition	FCD-3	Develop advanced engineering materials for use in waste packages in a variety of geologic media. Include multi-year test plans followed by reports describing tests and results of technical evaluations. Reports describing how engineered barriers survive various geologic environments.
FCR&D	FCR&D Fuels	FCF-1	*Advanced Fuel Design* - This element is primarily focused on design of innovative fuels and target forms for advanced reactors. The objective is to come up with fuel designs that can achieve higher performance requirements and multi-fold increases in burn-up than yet achieved, including the associated fabrication processes. The processes needed to fabricate the proposed fuel types are also within the scope of this program element. The university shall provide an advanced fuel design study (including fabrication process design) at the completion of this project.
FCR&D	FCR&D Fuels	FCF-2	*In Situ Instrumentation* – This element is focused on innovative *in situ* instrumentation design that can provide data during in-pile testing of fuels. Different phenomena in the fuel occur at different time-scales and the scope include instrumentation that can provide data on property changes in the earlier phase of irradiation as well as at later stages of burn-up. The university shall provide an advanced instrumentation prototype with complete laboratory testing at the completion of this project.

Program	Campaign	Work Scope ID. No.	Work Scope Description
FCR&D	FCR&D Fuels	FCF-3	*Characterization Equipment* – This element is focused on developing advanced characterization equipment that can be used with fuel samples (fresh and irradiated) where various thermal-mechanical properties of interest can be measured at micron scale (or lower-scale). The proposal may include modification to already existing equipment to enhance radiation tolerance or lower the length-scale of the measurement domain, as well as design of innovative concepts tailored for nuclear fuel applications. The university shall provide a prototype design tested with surrogate materials at the completion of this project.
FCR&D	FCR&D Materials	FCM-1	Develop advanced alloys or composites that can sustain multi-fold higher fluences. These alloys and composites are envisioned for use as reactor structural materials.
FCR&D	FCR&D Materials	FCM-2	*Aging and Stability Testing and Lifetime Modeling* – The microstructural stability of advanced structural materials must be validated at elevated temperatures and extended lifetimes. This requires specific testing of the candidate alloys under the anticipated operating characteristics and the development of semi-empirical modeling of fast reactor structural material aging and irradiation degradation mechanisms. Existing facilities should be able to perform this testing protocol. The university team will perform thermal aging and stability tests. These tests will assess the candidate alloys and be closely coordinated with the advanced alloy development. The university team will develop a structural material lifetime model and create a predictive computer code. This model will be extensively validated by comparison to existing reactor operating data and existing materials test. This model will capture fluence and temperature effects, but is not anticipated to be atomic level detail. Proposals may address the testing or modeling portion of this need or they may address both.
FCR&D	FCR&D Modeling and Simulation	FCMS-1	Development of multi-scale, multi-physics models for characterization of complex microstructural and thermomechanical phenomena pertinent to advanced fuels, waste forms, and geological environments.
FCR&D	FCR&D Modeling and Simulation	FCMS-2	Improvement of tools and framework to promote high-fidelity reactor modeling, including neutronics, structural dynamics, and thermo-hydraulics.

Program	Campaign	Work Scope ID. No.	Work Scope Description
FCR&D	FCR&D Modeling and Simulation	FCMS-3	Creation of methods and tools that will allow first principal simulation results, done at lower length scales (e.g. atomistic), to be coupled to higher level continuum-performance simulations at larger length and time scales. These methods and tools must be usable on advanced computational platforms.
FCR&D	FCR&D Modeling and Simulation	FCMS-4	Development of novel techniques for robust validation/verification and uncertainty quantification of advanced simulation tools leading to better defined confidence margins.
FCR&D	FCR&D Nuclear Physics and Theory Development	FCN-1	*Nuclear Theory and Modeling* – university teams will perform a systematic evaluation of how advanced measurement techniques can be used to help guide improved nuclear theory and theory, resulting in a strategic plan at the end of the first year. The following years will focus on nuclear model development with periodic reporting on validation and cross-section evaluation studies. The investments made in nuclear experiments can only be fully realized when evaluated in a more comprehensive theoretical treatment. This research topic will develop the capability to perform inclusive multi-channel nuclear physics evaluations, capable of delivering inter-reaction covariance data as a function of incident neutron energy. Improved nuclear models will be developed and validated in collaboration with the FCR&D nuclear physics team. In addition, these models will be employed to evaluate and construct new data sets for key fuel cycle nuclides.
FCR&D	FCR&D Nuclear Physics and Theory Development	FCN-2	*Improved Measurement Techniques* – This research topic will pursue advanced measurement techniques that could complement ongoing measurements. In particular, fission multiplicity and fission neutron spectrum measurements as a function of incident neutron energy have been identified as important data in recent sensitivity analyses. Innovative ideas for detector development and testing are needed to facilitate the high fidelity requirements of the FCR&D effort. University teams will develop new measurement systems to address the data needs noted above. Candidate systems will be reviewed and refined in conjunction with the FCR&D nuclear physics team. The following years will focus on construction and testing of a prototype device.

Program	Campaign	Work Scope ID. No.	Work Scope Description
FCR&D	FCR&D Nuclear Physics and Theory Development	FCN-3	*Revolutionary Transmutation Concepts* – Investigate innovative methods for fission product transmutation. Nuclear physics may be able to play a role in the reduction of highly radioactive waste by transmutation or other means. Novel methods are being sought to help minimize the heat load from fission products in separated, processed waste. Such methods could include techniques other than neutron irradiation. University teams will need to propose and study methods for nuclear transmutation of fission products in conjunction with the FCR&D nuclear physics team.
FCR&D	FCR&D MPACT	FCP-1	New sensor materials and measurement techniques for nuclear materials control and accountability (including process monitoring) are needed. This task includes development, design, and testing of devices with increasing sensitivity, resolution, radiation hardness, and lowered cost of manufacture. Areas of interest include 1) sensors based on radiation detection; 2) sensors based on other detection methods (such as optical or thermal, etc.) techniques; 3) new active interrogation methods, including basic nuclear data (neutron and photo fission, nuclear resonance fluorescence); and 4) non-radiation based techniques such as stimulated Raman, laser-induced breakdown spectroscopy, fluorescence, etc.
FCR&D	FCR&D MPACT	FCP-2	Need to develop new methods for data validation and security data integration, and real-time analysis with defense-in-depth and knowledge development for the facility operations under normal and off-normal conditions: 1) information validation and security; 2) quantitative integration of disparate data; and 3) real-time analysis, review, and notification.
FCR&D	FCR&D MPACT	FCP-3	Develop online, real-time, continuous accountability instruments and techniques that support the challenge of permitting significant improvements in the ability to inventory fissile materials in domestic fuel cycle systems in order to detect diversion and prevent misuse.

Program	Campaign	Work Scope ID. No.	Work Scope Description
FCR&D	FCR&D MPACT	FCP-4	*Proliferation Risk Assessment* – Proliferation "resistance," and associated proliferation risk, is a concept that expresses the relative measure of the confidence that nuclear material or technology cannot be easily misused. An opportunity exists to integrate across traditional boundaries to achieve major advances in capabilities to develop and conduct proliferation risk assessments and subsequently optimize advanced nuclear energy systems from a proliferation risk reduction perspective. The ultimate goal of this effort will be to develop and use new analytical tools that could revolutionize our ability to compare the proliferation risk of nuclear energy systems in a way that is comprehensive and communicable. For such tools to be comprehensive, they should include professional socio-political analyses that open an avenue to study the reasons for public concern, and the effect of public perception on the viability of advanced nuclear fuel cycles. The universities will define, develop, and demonstrate a multi-faceted risk assessment approach for evaluating the proliferation risks and sociological factors associated with the nuclear fuel cycle.
FCR&D	FCR&D Separations & Waste Forms	FCS-1	Investigate fundamental interfacial electrochemistry of actinides and fission product elements important in the fuel treatment process; for example, determination of thermodynamic properties in process relevant molten salts (e.g., LiCl, LiCl-KCl) or characterization of kinetics and mass transport properties of important species in process relevant molten salts. Collection of fundamental data to support better data and understanding of electrochemical separation methods is needed. Investigate alternate aqueous and dry processes, including those based on volatility and ionic liquids. Apply modeling and simulation to the identification of alternate ligands for solvent extraction applications.
FCR&D	FCR&D Separations & Waste Forms	FCS-2	Develop new and innovative methods for the capture and immobilization of volatile fission products (iodine tritium, krypton, and carbon-14) from used nuclear fuel off-gas (during shearing and dissolution). New adsorbents or separation technology for isolating and concentrating captured volatile off-gas species. Report describing technical results and efficacy of new technology.

Program	Campaign	Work Scope ID. No.	Work Scope Description
FCR&D	FCR&D Separations & Waste Forms	FCS-3	Develop novel separations methods for gas reactor (SiC or TRISO) fuels; investigate transformational separations technologies; or develop a fundamental understanding of An(III) separation from Ln(III) elements. Investigate advanced methods of exposing the actinide content of TRISO fuel kernels to chemical treatment.
FCR&D	FCR&D Separations & Waste Forms	FCS-4	Develop a fundamental understanding of waste form stability over geologic time scales, including effects of various stresses—elevated temperature, the decay of radionuclides into other elements, high radiation fields, and other varying environmental conditions—leading to the prediction of radionuclide release over millennia. The focus of this work scope is on engineered waste form performance.
FCR&D	FCR&D Separations & Waste Forms	FCS-5	Develop and test next generation of nuclear waste forms capable of radionuclide immobilization, with simple remote fabrication capability and predictable performance. Evaluate the recycle of commercially valuable components of used nuclear fuel.
FCR&D	Systems Analysis	FCSA-1	Development of science-based metrics – The metrics currently used in the program include things such as fuel cycle cost, waste volume, radiotoxicity, and decay heat. These metrics have been used to develop system level requirements, however for the most part, they do not have a scientific basis and do not enable comparison across energy options. In addition to individual metrics, an aggregate fuel cycle “indicator” is desired that combines the individual metrics.
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4A-1	High temperature materials are required to accommodate the high helium outlet temperatures in a VHTR that is needed for process heat and hydrogen production. Aging and environmental effects are required to fully characterize the behavior of these alloys in VHTRs. Experiments are sought that will help elucidate mechanisms of environmental embrittlement of candidate high temperature alloys. Alternatives to chromia forming alloys are also sought for high temperature environments. Methods are needed for accelerated testing/simulation of very long term aging behavior. Materials/approaches also are sought to improve the resistance of protective oxides to thermal cycling/high velocity gas/particulate erosion.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4A-2	For pressure vessel steels to be used in VHTRs, experimental, calculational, and NDE methods are needed to characterize negligible creep in pressure vessel steels. NDE methods are sought to characterize microstructures in heavy section ferritic-martensitic steels. Methods for modifying and controlling pressure vessel emissivity are required. In the longer term, evaluations of more advanced high temperature, high strength metals (steels, alloys) for VHTR reactor pressure vessel applications that are robust, reliable, cost-effective, and amenable for modular multiple manufacturing techniques (including ring forging, field welding/joining, and heat treatment) are sought. The development and characterization of advanced joining techniques for ODS alloys, ferritic-martensitic steels, or advanced austenitics are also welcome.
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4A-3	High temperature materials are required to accommodate the high helium outlet temperatures in a VHTR that is needed for process heat and hydrogen production. Mechanical properties of Ni based alloys are under consideration. Experiments are sought to better understand the mechanisms of dynamic strain aging in high temperature alloys and the mechanisms of strain localization and creep cavitations in high temperature materials. New strategies are required for creep resistant alloys at 1,000°C and above. Proposals that establish microstructure/properties/processing relationships in diffusion bonding and brazing Ni-based alloys are also welcome. Constitutive models need to be developed for creep-fatigue of Ni based alloys.
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4A-4	Graphite is the structural material for VHTRs. As such, *in situ* NDE is required to characterize and/or verify its structural adequacy. Proposals are sought that will develop NDE techniques viable for 1) detecting disparate flaws such as voids, large inclusions, and large crack in large graphite components or billets; 2) degradation of thermal properties (i.e. conductivity/resistivity) and stress build-up in graphite; and 3) detecting fiber damage or fiber/matrix damage within composites.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4A-5	Composites are under consideration for use in high temperature locations in VHTRs. Experiments are sought to measure creep rupture properties of nuclear grade composite and composite joint structures. Long-term effects of the nuclear environment on the thermal barrier integrity of fibrous insulation materials are also of interest. Proposals that focus on the development of irradiation resistant, continuous fiber reinforced composites (SiC/ SiC, ceramic and Carbon-based) are also welcome.
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4A-6	For ceramics to be used in HTGRs, improvements in analytic models to describe performance, degradation, and failure are required. Areas of interest include the following: • Simulation of the maturation of defect structures in graphite crystalline grains and bulk material strain, stress, and creep effects, including neutron cascading, graphite growth, and shrinkage • Benchmark modeling microstructure effects against experimentally verified results of highly penetrating ion irradiation damage • Failure prediction methodologies for composite materials under impure helium environments and irradiation, including SiC/SiC composites, under oxidative attack, irradiation-induced creep, and progressive load shifting with crack propagation • Determination of SiC and carbon fiber composite dimensional stability, anisotropic dimensional changes, and fiber and matrix integrity, in terms of effective composite lifetime, and failure modes
GEN IV	Gen IV Advanced Reactor Concepts: Advanced High Temperature Reactor	G4B-1	Advanced high-temperature reactors combine the coated particle fuel and graphite moderator of the VHTR with a liquid fluoride salt as a coolant. R&D activities are focused on establishing the concept's viability and selecting promising technologies. A key difference between salt and helium cooling is considerable increase in the heat transfer rate out of the fuel allowing for a 4-8x increase in power density which translates into higher cycle efficiency and smaller cores for modular fabrication. The higher density also places much greater demands on TRISO fuel performance. Research is needed to compare AHTR and VHTR coated particle fuel design requirements and to develop and test high flux, high power fuel.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Advanced Reactor Concepts: Advanced High Temperature Reactor	G4B-2	Advanced high-temperature reactors combine the coated particle fuel and graphite moderator of the VHTR with a liquid fluoride salt as a coolant. R&D activities are focused on establishing the concept's viability and selecting promising technologies. A key viability engineering issue for the system is valves. Liquid salt mechanical valves do not currently exist for AHTR conditions. Candidate valve design, development, and testing are required.
GEN IV	GEN IV Advanced Reactor Concepts: Advanced High Temperature Reactor	G4B-3	Advanced high-temperature reactors combine the coated particle fuel and graphite moderator of the VHTR with a liquid fluoride salt as a coolant. R&D activities are focused on establishing the concept's viability and selecting promising technologies. Structural materials (alloys) compatible with liquid fluoride salts need to be qualified. Currently, the most promising structural material approach for AHTRs is to clad alloys qualified under the VHTR program (Alloy 800H or 617) with nickel. Molybdenum alloys are also chemically compatible with fluoride salts above 1,000°C. A significant amount of information on MSR salt chemistry and its impact on metallic corrosion is available from both the MSRE and more recent development activities. Proposals are sought in the areas of (a) development and demonstration of materials technology for cladding shaped and joined structures, (b) multi-component, dynamic fluoride computational chemical analysis to improve the understanding of corrosion in this complex system, and (c) new methods of analyzing fluoride salt chemistry and salt purification systems.
GEN IV	GEN IV Advanced Reactor Concepts: Advanced High Temperature Reactor	G4B-4	Advanced high-temperature reactors combine the coated particle fuel and graphite moderator of the VHTR with a liquid fluoride salt as a coolant. R&D activities are focused on establishing the concept's viability and selecting promising technologies. Few existing instruments will perform under the high-temperature liquid fluoride salt environment. Research and development of salt-wetted instrumentation for both operations (high accuracy temperature, flow, and neutron flux) and maintenance is required.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Fuels	G4F-1	TRISO-coated particle fuel is a robust fuel form with high fission product retentiveness. Experimental and theoretical approaches that establish credible fission product transport mechanisms to support the development of a mechanistic source term for VHTRs under normal, accident and off-normal conditions, including both air and/or moisture ingress events, are required. Specifically, (a) first principles computer models (kmc, atomistic) for fission product transport (Ag Cs, I, Te, Eu, Sr) through the TRISO particle SiC layer and graphitic material (fuel pyrolytic carbon, fuel matrix and core graphite) and (b) studies of fission product/ZrC interactions for key fission products of interest (Ag Cs, I, Te, Eu, Sr).
GEN IV	Gen IV Fuels	G4F-2	Key safety functions for VHTRs designed for process heat applications are control for external oxidants (air and moisture). Mechanistic computer models are needed to improve the current empirical understanding of the influence of air and moisture ingress on fission product transport in TRISO particle pyrolytic graphite and graphite block or pebble outer graphite layer.
GEN IV	Gen IV Fuels	G4F-3	A deep-burn VHTR has as its goal the development of a high burnup TRISO-like fuel particle to support transmutation missions. Proposals are sought in the following areas: (a) innovative deep-burn TRISO fuel particle designs (e.g., TRIZO, TRIZO*, dispersed burnable absorbers or fission product getter materials); (b) studies of the associated performance of the innovative fuel designs; (c) studies of fission product/ZrC interactions; and (d) characterization of thermomechanical and thermophysical properties of ZrC (both unirradiated and irradiated), a potential candidate material to replace SiC in the coated particle.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4H-1	Supercritical CO_2 shows promise as a working fluid suitable for fast and thermal reactors because of its compatibility with materials and thermodynamic properties. Basic R&D is needed in turbomachinery performance and loss mechanisms in reactors. Development and testing of computer models for supercritical CO_2 Brayton cycle energy technologies is sought. For new energy conversion technology, system optimization requires a detailed modeling of the system components and their response to steady-state and off-normal conditions. The university participants could contribute detailed CFD modeling of key components, such as the main compressor, for comparison to one-dimensional system level models and experimental data from ongoing small-scale testing. Alternately, contributions could be made to the development of plant dynamics models and control strategies, including the investigation of alternative cycle layouts (e.g., having turbomachinery on multiple shafts). The efficiency of different power conversion cycles is degraded by leaks at component interfaces. R&D is needed to develop models and/or test beds to predict the performance of seals (labyrinth, dry liftoff seal, brush, etc.) and bearings. The economics of different power conversion cycles is a strong function of turbomachinery efficiency and durability. R&D is needed to develop models for turbomachinery bearings (gas foil, magnetic, and hydrodynamic) and S-CO_2 windage loss.
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4H-2	AHTRs and liquid metal systems rely on direct reactor auxiliary cooling as part of the ultimate heat sink in their design. Given the importance of this system to the overall safety of these concepts, proposals are sought that would design, simulate, and demonstrate the performance of these systems under prototypic conditions.
GEN IV	Gen IV Heat Transport, Energy Conversion, Nuclear Heat Applications	G4H-3	The VHTR is well suited for the co-generation of process heat and electricity and for the production of hydrogen from water for industrial applications in the chemical and petrochemical sectors. A mature infrastructure exists for using and transporting transportation and heating fuels. With the VHTR/HTGR as a source of process heat, optimization of VHTR for heat process applications is required. Development of approaches to coupling of the heat source with the wide variety of process heat applications (co-generation, coal-to-liquids, chemical feedstocks) is sought with an emphasis on novel approaches that can greatly improve the ease of coupling, the operability of the combined system, and the ultimate economics.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	GENIV Fast Reactors	G4L-1	The microstructure stability of advanced structural materials must be validated for fast reactors at elevated temperatures and extended lifetimes. Semi-empirical modeling of fast reactor structural material aging and irradiation degradation mechanisms need to be developed to predict high neutron fluence and temperature effects and bulk/macrostructural mechanical properties, including yield strength, creep, fatigue, ductility, etc., as a function of time, temperature, irradiation damage, and pressure history. Validation and verification of the micro-structural stability of advanced structural materials operating at high temperature, high neutron damage conditions for extended operating lifetimes for anticipated fast reactor operating conditions.
GEN IV	GENIV Fast Reactors	G4L-2	A supercritical CO_2 cycle is under consideration as part of the power conversion system in a fast reactor system. Experiments to study corrosion chemistry and establish the performance limits of candidate metallic alloys in CO_2 are needed.
GEN IV	Gen IV Methods (NGNP): Design and Analysis Methods for High Temperature Reactors and Coupled Process Heat Plant Dynamics	G4M-1	The VHTR is well suited for the co-generation of process heat and electricity and for the production of hydrogen from water for industrial applications in the chemical and petrochemical sectors. The understanding of the implications of coupling the VHTR to the industrial process is lacking. Analysis of the dynamic (coupled) simulation of reactor-driven process heat plants, including load matching and rejection, process upsets, and use of multiple modules is requested.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Methods (NGNP): Design and Analysis Methods for High Temperature Reactors and Coupled Process Heat Plant Dynamics	G4M-2	The neutronic behavior of current annular VHTR cores is different from LWRs and fast reactors. Methods for efficient coupling of assembly and core simulator codes is needed for optically thin cores. Methods that account for burnable poisons and control rods is needed in nodal kinetics codes for prismatic VHTRs. Fuel management techniques (i.e., block/fuel placement and core loading/refueling strategies) and fuel cycle optimization (i.e. fissile fertile, burnable poison loading, uranium utilization, transuranic fuel consumption) approaches for prismatic VHTR cores need to be developed. New approaches are also sought to neutron slowing-down, resonance region interactions, and neutron upscatter in reactors. Cross-section measurement and validation in isotopes prominent in high burnup fuels are also needed.
GEN IV	Gen IV Methods (NGNP): Design and Analysis Methods for High Temperature Reactors and Coupled Process Heat Plant Dynamics	G4M-3	There are very few high fidelity system level analyses of VHTRs to understand, at a more detailed level, some of the more complex transients in VHTRs. High resolution, time-dependent multiphysics analysis of pipe breaks in VHTRs that account for helium blowdown, water ingress, and fission product/dust transport are sought to better understand phenomena that occur in these events.
GEN IV	Gen IV Methods (NGNP): Design and Analysis Methods for High Temperature Reactors and Coupled Process Heat Plant Dynamics	G4M-4	This research area will pursue advanced techniques for measuring VHTR/HTGR core temperature and flux, especially for recirculating pebble bed reactors.

Program	Campaign	Work Scope ID. No.	Work Scope Description
GEN IV	Gen IV Methods (NGNP): Design and Analysis Methods for High Temperature Reactors and Coupled Process Heat Plant Dynamics	G4M-5	Scaled thermal hydraulic experiments will be performed to provide experimental validation of important accidents in scenarios in a VHTR as required for licensing. As part of these experiments, proposals are sought to support scaling, experimental design, and fundamental phenomena identification for core/vessel behavior in depressurized and pressurized conduction cooldown scenarios, performance of the VHTR reactor cavity cooling system, mixing in the lower plenum, heat transfer in the core and the associated core bypass flows under normal operation, natural circulation in the reactor under pressurized conduction cooldown conditions, and air ingress events.
GEN IV	Gen IV SMR	G4S-1	Development of new concepts that utilize advanced technologies or innovative engineering is sought and should be viable for commercial deployment by as early as 2018, but no later than 2030. The scope of the proposed project should include a thorough viability assessment of the concept, a detailed technology gap analysis, and a comprehensive technology development roadmap.
GEN IV	Gen IV Thermal Transmutation Systems	G4T-1	Studies are requested to explore the potential for transmutation in thermal reactor systems, especially VHTRs, to compliment the VHTR deep burn program element. Proposals are sought to (a) explore the fuel/core designs in these systems that maximize plutonium and minor actinide destruction while retaining passive safety and improving the fuel economy, and proliferation resistance; and (b) examine novel thorium-fueled cycles that minimize the need for isotope separation/recycling yet develop mitigation strategies for the gamma dose from U-233.

Program	Campaign	Work Scope ID. No.	Work Scope Description
	LWR Sustainability	LWS-1	Evaluation of flux effects and high fluence degradation of reactor pressure vessel (RPV) steels. Evaluating high fluence effects (embrittlement and/or late blooming phases) is essential in ensuring reactor pressure vessel integrity for operation beyond 60 years. Evaluation of high fluence specimens (from past industrial capsules or campaigns) and single variable experiments may be required to evaluate the potential for embrittlement and to provide a better mechanistic understanding of this form of degradation. Testing may include impact and fracture toughness evaluations, hardness, and microstructural analysis. Modeling of microstructural changes and mechanical performance is also an important need. New methods to generate meaningful data out of previously-tested RPV specimens are needed. Alternative methods for surveillance testing should also be evaluated. Methods for modifying activated RPV specimens currently located ex-core to extract smaller samples, keeping remaining coupon pieces in service, are encouraged. Universities engaging in this effort will be expected to produce data or mechanistic modeling to help reduce the uncertainty associated with the long-term aging of reactor pressure vessel steels.
	LWR Sustainability	LWS-2	Analysis of concrete performance in LWR applications – universities engaging in this effort will be expected to produce data or mechanistic modeling to help reduce the uncertainty associated with the long-term aging and performance of concrete. The long-term stability and performance of concrete structures within a nuclear power plant is a concern because there is little operational data or experience to inform relicensing decisions. The collection of samples from aging (or decommissioned) plants or other nuclear facilities will provide valuable information on the long-term performance of aging nuclear power plant structures. The interface between concrete structures and metal components is also of high technical interest. This work will support the LWRS program strategic goals by providing key data and mechanistic understanding on concrete degradation phenomena that may occur based on current knowledge. A more complete mechanistic understanding of this degradation mode will be critical to reducing uncertainty and providing reliable long-term predictions for this irreplaceable reactor component.

Program	Campaign	Work Scope ID. No.	Work Scope Description
	LWR Sustainability	LWS-3	Mechanistic understanding of embrittlement via microstructural instability (phase transformations) in high fluence austenitic stainless steel components – a predictive model will provide insight into embrittlement caused by microstructural changes. The relationship among microstructure, hardening, and embrittlement must also be explored. This work will support the LWRS program strategic goals by providing key data and mechanistic understanding of irradiation-induced effects, which are expected to become more severe with extended service beyond 60 years of lifetime. This work also provides data and a mechanistic understanding to enhance the current state of knowledge of irradiation-induced embrittlement and inform life extension decision processes. Universities engaging in this effort will be expected to produce data or mechanistic modeling to help reduce the uncertainty associated with the long-term irradiation of nuclear reactor core-internals.
	LWR Sustainability	LWS-4	*Advanced Online Monitoring Survey* – The research will focus on NDE methods that will provide techniques to examine, or monitor in real time, those effects being studied in the advanced nuclear fuels pathway, including fission gas release and transport, pellet-clad interaction, cladding oxidation, crud formation, corrosion, hydrogen embrittlement, and failure. This research will develop inspection capabilities for reactor monitoring. The ability to monitor aspects of ductility loss in used fuel cladding while in storage is an example of this program element. Universities performing this research will be expected to produce results that integrate multiple mechanistic processes.

Program	Campaign	Work Scope ID. No.	Work Scope Description
LWRS	LWR Sustainability	LWS-5	*Advanced Designs and Concepts for Fuel and Cladding* - The purpose of this task area is to increase the understanding of advanced fuel design concepts, including the use of new cladding materials; to increase fuel lifetime; and to expand the allowable fuel performance envelope. These improvements will then allow the fuel performance related plant operating limits to be optimized in areas such as operating temperatures, power densities, power ramp rates, and coolant chemistry (CC). Accomplishing these goals leads to improvement of operating safety margins and improved economic benefits. R&D in this area should include the development of specific technologies for advanced nuclear fuels and the benchmarking and test activities for the developed computer models. This task consists of testing advanced fuel designs and features in prototype forms. The goal is to demonstrate design features that can be utilized in advanced nuclear fuels. The benchmarking is intended to provide confidence in the derived computer models and to make accurate applications possible. Universities performing this research will be expected to produce results that integrate multiple mechanistic processes and will have to work closely with the LWRS Program Office.

Program	Campaign	Work Scope ID. No.	Work Scope Description
	LWR Sustainability	LWS-6	*Fuels Modeling Efforts* – central to the advanced LWR nuclear fuel development R&D pathway is the development and use of fuel performance models, which is key to the success of other program elements such as fission gas release and swelling, CC accelerated corrosion and crud deposition, and PCI. This program element should lead to developing high fidelity models and interfaces between neutronics, thermal hydraulics, fluid dynamics, and CC. Development of these models should be adaptable to complicated design geometry such as part-length rods, different rod lengths, and impact of increased power and flow uncertainties. Three-dimensional models should also be developed with equivalent spatial and temporal resolution and expandability of current 2-D models. The high fidelity modeling should include material behavior (constitutive) models and numerics for multiple special geometries (2-D r-z + r-theta with materials modeling and axial splicing/interaction). To ensure modeling efforts benefit all users from industry, academia, national laboratories, and the DOE, data and code should be publicly available, provide code portability using simplified subroutines for higher-length scale codes, and define inputs and outputs of each length-scale modeling tool. Universities engaging in this effort will be expected to produce data or mechanistic modeling to help reduce the uncertainty associated with the long-term aging of reactor pressure vessel steels.
	LWR Sustainability	LWS-7	R&D should address the Risk-Informed Safety Margin Characterization (RISMC) methodology and capability gaps in probabilistic risk analysis (PRA) and deterministic safety analysis to enable effective implementation of RISMC in practice. Areas of high priority include the following: 1) a comprehensive methodology to characterize nuclear power plant safety margins in the risk-informed framework and determine how these margins could change over the plant extended operation; 2) effective techniques for dynamic PRA and inclusion of reliability of passive systems and components; and 3) advanced modeling and simulation methods to support the development, verification, and validation of next-generation system safety codes that enable the nuclear power industry to perform analysis of a nuclear power plant's transients and accidents with a high degree of confidence. Universities performing this research will be expected to produce results that integrate multiple mechanistic processes.

Program	Campaign	Work Scope ID. No.	Work Scope Description
	LWR Sustainability	LWS-8	Digital instrumentation and control technologies for improved monitoring and reliability. Research is needed to improve upon available methods for online monitoring of nuclear plant systems, including physical structures that are critical to safety, as well as control system reliability. Research should investigate the use of advanced prognostic technologies for monitoring and predicting system health and performance, as well as methods needed to analyze the reliability of integrated hardware/software technologies that comprise digital systems. High priority research areas include the following: 1) prognostic methods that can be deployed for monitoring nuclear plant systems, structures, and components, and that can be demonstrated in test bed environments representative of nuclear plant applications; and 2) methods for analyzing the dynamic reliability of digital systems, including hardware and software systems based on formal methods that can be demonstrated on systems that are proposed or representative of systems proposed for nuclear plant control and automation. This research is expected to support the development of methods and technologies to support digital instrumentation and control integration for monitoring and control as well as for noting areas of improved reliability and areas requiring further information and research. Universities performing this research will be expected to produce results that integrate multiple mechanistic processes.
All	N/A	MR-IIR	Nuclear energy mission relevant, creative, innovative, and "blue sky" research. This area includes research in the fields or disciplines of nuclear science and engineering such as, but not limited to, Nuclear Engineering, Nuclear Physics, Health Physics, Nuclear Materials Science, Radiochemistry or Nuclear Chemistry that are relevant to NE's mission though may not fully align with the specific initiatives and programs identified in this solicitation. Examples of topics of interest are new reactor designs and technologies; advanced fuel cycles, including advanced nuclear fuels; alternate aqueous and dry processes, including volatility and ionic liquids; instrumentation and control/human factors; radiochemistry; and fundamental nuclear science.